DOCUMENT RESUME

ED 272 308 PS 015 951

AUTHOR	Schroder, Eberhard; Edelstein, Wolfgang
TITLE	Analysis of Developmental Sequences within the Structural Approach: Conceptual, Empirical, and Methodological Considerations.
PUB DATE	May 86
NOTE	28p.; Paper presented at the Annual Symposium of the Jean Piaget Society (16th, Philadelphia, PA, May 29-31, 1986).
PUB TYPE	Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Child Development; Cognitive Ability; *Cognitive Development; Foreign Countries; Longitudinal Studies; Models; Profiles; *Research Methodology
IDENTIFIERS	*Conceptual Analysis; *Developmental Sequences; Iceland

ABSTRACT

In this paper conceptual and methodological issues in the analysis of developmental sequences are discussed. Conceptually, the reconstruction of the logic of acquisition calls for the use of task or structure analysis. Methodologically, it calls for an individual-oriented approach, the use of statement calculus for formulation of the postulated developmental relationships, and confirmatory fitting of the developmental model. This approach is illustrated by longitudinal data of operatory intelligence collected in an Icelandic sample of 121 children 7, 9, and 12 years of age. Structural relationships between different concrete- and formal-operational abilities are specified with respect to the synchronous and diachronous development. The postulated relations are validated by structure analysis and integrated into a consistent model of operatory development. This model represents intraindividual courses or profiles of cognitive development, and on an aggregate level the formation processes of emerging operativity. (Author/RH)

Analysis of Developmental Sequences Within the Structural Approach: Conceptual, Empirical, and Methodological Considerations

Eberhard Schröder & Wolfgang Edelstein

Max Planck Institute for Human Development and Education

Berlin, F.R.G.

Running Head: Developmental Sequences

Paper presented at the Sixteenth Annual Symposium of the Jean Piaget Society, May 29-31, 1986, Philadelphia, USA.

Abstract

Analysis of developmental sequences is central to a theory of cognitive development according to Piaget. The concept of developmental sequences characterizes such ordered successions of developmental steps that are theoretically defined by the regularity of their occurence. Analysis of developmental sequences focuses on the internal dynamics of development and the intraindividual changes in the domains investigated. In this paper conceptual and methodological issues in the analysis of developmental sequences are discussed. Conceptually, the reconstruction of the logic of acquisition calls for the use of task or structure analysis. Methodologically, it calls for an individual-oriented approach, the use of statement calculus for formulation of the postulated developmental relationships, and confirmatory fitting of the developmental model. This approach is illustrated by longitudinal data of operatory intelligence collected in an Icelandic sample of children (N = 121) aged 7, 9 and 12. Structural relationships between different concrete- and formal-operational abilities are specified with respect to the synchronous and diachronous development. The postulated relations are validated by structure analysis and integrated into a consistent model of operatory development. This model represents intraindividual courses or profiles of cognitive development, and on an aggregate level the formation processes of emerging operativity.

Analysis of Developmental Sequences in Cognition:

Conceptual, Empirical, and Methodological Considerations

Conceptual and methodological considerations

Constructs of developmental sequence and stage are central to the theory of cognitive development since they document intraindividual changes in the acquisition of cognitive operations. Within the framework of genetic epistemology, the concept of sequence means the ordered acquisition of distinct developmental steps or stages. Two types of developmental sequences, precursor sequences and prerequisite structures are postulated (Campbell & Richie, 1983). Precursor sequences reflect merely the empirical order in the acquisition of tasks. This implies that some tasks are easier to solve than others, since specific performance conditions (difficulty of tasks or presentation modes) result in differences when solving the tasks. The postulation of a prerequisite structure, however, requires structural or functional analysis of the relations between operations. Conceptual arguments are needed to validate the interrelationship examined. Therefore, the concept of developmental sequence commands an explanatory status only if theoretical and conceptual arguments support the postulated order of acquisition stages. Such arguments are, therefore, prerequisite conditions for meaningful empirical analyses of developmental sequences.

The construct of developmental sequence refers to the functional or formal (structural) aspects of development. It not only represents inclusive or implicative relationships between developmental variables, but it also represents synchronous acquisition sequences of different abilities in form of point- or interval-synchronies (Fischer & Bullock, 1981).

A review of empirical research shows that assumptions about sequentiality in the emergence of cognitive operations are mostly based on the analysis of group sequentiality in one-group designs or across-group-sequentiality in cross-sectional-designs. Few studies examine intraindividual change, although sequence hypotheses focus explicitly on this perspective of individual development. To emphasize this argument, hypotheses dealing with intraindividual changes will be represented within the methodological framework of Buss (1979). There are three analytical dimensions which are relevant in the analysis of individual development, namely, the person (individual), the dimension (developmental variables), and the measurement occasions. According to Buss (1979), intraindividual changes and differences in development can only be analyzed with respect to the following types of data-aggregations:

case 1: Interindividual differences in intraindividual differences, in which individuals are compared in terms of sampling across variables at one occasion.

case 5: Interindividual differences in intraindividual changes, in which individuals are compared in terms of sampling across occasions for one variable.

Figure 1 shows both analytical perspectives within a three-dimensional data-matrix whereby persons by variables by occasions are aggregated (see also Schröder, 1986). Synchronous and diachronous development are specified and distinguished.

Insert Figure 1 about here

In the following discussion, hypotheses of the first type will be called Configuration hypotheses or synchronous profiles and assumptions of the second type Constellation hypotheses or diachronous profiles.

Three different procedures have been used for statistical evaluation of sequence hypotheses (see Spiro, 1984). These strategies are:

1) Difference-testing procedures: Differences in one or more developmental variables in different age groups are taken as evidence of intraindividual changes in development. The inference from the developmental function of a population or sample to intraindividual changes within the subjects is valid only if the developmental function of the group is congruent to those of the individuals. This implicit assumption is unlikely, since interindividual differences exist between the individual

developmental courses that are not revealed in the global developmental function (Bakan, 1967). Therefore, developmental paths of the individual cannot be predicted or approximated by the developmental function of the group.

2) Correlational procedures: According to Winer (1981) correlational testing procedures are appropriate to analysis of developmental sequences since they focus on the functional or formal (structural) relations between developmental variables. Correlations are taken to represent the degree of consistency between variables or stability over time. However, conclusions of sequential relationships in data-matrices are not justifiable by correlational analysis, since hierarchical relations between variables could exist without statistically significant covariations between those variables (Edelstein, Keller & Wahlen, 1984; Henning, 1981; Hudson, 1978; Rudinger, 1978).

3) Unidimensional Guttmann Scaling: This procedure is adequate for analysis of developmental sequences since it takes into account the individual patterns or configurations. Each individual can be definitively classified on the developmental scale. Unfortunately, Guttmann-scaling is restricted to transitive (linear) relationships and does not allow investigation of cumulative or synchrony relationships. Further, it is not readily applicable to the longitudinal analysis of developmental sequences.

Since these procedures do not analyze intraindividual change, new empirical and methodological strategies have been developed which are more appropriate to analysis of developmental sequences (Bart & Airasian, 1974; Bart & Krus, 1973; Dayton & McReady, 1976; Hildebrand, Laing & Rosenthal, 1977; Rudinger, Chaselong, Zimmermann & Henning, 1985; von Eye & Brandtstädter, 1985). These procedures, deriving partly from the fields of biostatistics, latent attribute scaling or order theory, are appropriate to categorial data. In comparison with the often used parametric statistics these procedures can be characterized systematically by the distinction between variable- and person-(individual-) oriented approaches (Bergman & Magnusson, 1983; Magnusson, 1985). Within the individual-oriented approach, assumptions of individual development can be formulated and expressed in terms of configuration or constellation-hypotheses based on intraindividual developmental change according to Buss' (1979) methodological framework. In this case the variables will be aggregated to form specific configurations of attributes or constellations of time occasions which represent appropriate individual courses of development with respect to a synchronous or a diachronous perspective of development.

Within the individual-oriented approach the formal functional relations between variables or time occasions, as postulated and validated by structure or task analysis, can be formulated in terms of a statement calculus. The formulation by

logical propositions allows the specification of occurring patterns as admissible or inadmissible according to the sequence hypothesis. For example, if attribute A is the precursor of B (A and B coded in dichotomous form) the combination of non-A and B is inadmissible due to the implicative relationship of A and B. The other three combinations (A B, A non-B and non A non-B) are admissible, since they do not contradict the sequence hypothesis. In Figure 2 the first contingency table represents an implicative relation between two developmental variables A and B. The second contingency table in Figure 2 represents the replicative relation (cumulativity) between two measurement occasions A1 and A2. The error cells are barred.

Insert Figure 2 about here

These examples of bivariate relations can easily be extended to multivariate relationships (see also Schröder, 1986). Additionally, different types of relations could be specified.

In the following section the approach of analyzing developmental sequences as described above will be illustrated by an empirical example taken from the study of operatory development. It should evidence how structural relationships between developmental variables are specified with respect to synchronous and diachronous perspectives of individual development and how the resulting model of operatory development is fitted

statistically to the observed profiles of acquisition by the probabalistic validation procedure of Dayton and MacReady (1976).

Example

Subjects and instrumentation

In a longitudinal study conducted in Reykjavik, Iceland, a number of Piagetian tasks was presented to 60 girls and 61 boys at ages 7, 9 and 12 (Edelstein, Schröder, Kliegl, Spellbrink, Zebergs & Baker, 1984). The following tasks were administered: Conservation (Goldschmid & Bentler, 1968) at age of 7, Class Inclusion (Smedslund, 1964) at ages 7 and 9, Multiplicative Compensation (Invariance of Volume: Piaget & Inhelder, 1975) at ages 9 and 12 and the Pendulum Task (Piaget & Inhelder, 1977; Somerville, 1974) at age 12. All tasks were administered individually. In accordance with Piagetian theory, dichotomous competence scores were given for subjects' explanations of their judgments.

The longitudinal measurement design of the study is shown in Figure 3. Depending on the presumed general developmental status of the age groups different concrete- or formal-operational tests were presented at ages 7, 9 or 12. They cover cognitive abilities appropriate to the age groups. The four operational concepts investigated in the analysis of developmental sequence are described as follows:

Insert Figure 3 about here

Conservation: early or emerging concrete-operational ability; quantity has to be conserved (without a second reference system) by compensation or reversibility (identity).

Class Inclusion: mature concrete-operational ability; addition of classes and classification of hierarchically ordered attributes.

Multiple Compensation: early or emerging formal-operational ability; volume has to be conserved within a second reference system (decompensation of water) by multiple compensation; the conservation judgment must be transferred to a second frame of reference.

Pendulum Task: mature formal-operational ability; identification of operative variables within a multivariate system by controlling operative variables and exclusion of inoperative variables by applying propositional logic (hypothetical and deductive thinking using verification and falsification experimentally).

Developmental hypotheses and the formulation of a model of operatory development

For the specification of synchronous and diachronous structural relationships between these four developmental variables the following assumptions were made:

Synchronous development (interrelations of variables at one measurement occasion)

1) Concerning concrete operational tasks· The operation of addition and inclusion of classes implies the operation of conservation since through the addition of bc ' subclasses A1 + A2 = B the different, but hierarchically ordered classificatory attributes must be conserved. According to this decalage hypothesis, Conservation is a necessary condition (or prerequisite structure) for the emergence of Class Inclusion and has to be acquired earlier than Conservation. With respect to the binary-matrix shown above, the following combination is inadmissible to the developmental hypothesis: Class Inclusion is acquired, but subject is unable to give an explanatory statement about Conservation (see also Fig. 2; Pattern I).

2) Concerning the formal-operational tasks: It was assumed that Multiple Compensation is easier to acquire and thus acquired earlier than identification of operative variables. Conservation of volume requires decompensation in a second reference system, whereby the Penduium Task calls for the exclusion of variables and the deduction of operative variables within a multivariate reference system. Since in the Pendulum Task subjects must process and coordinate much more information than in the compensatory operation, we postulate that Multiple Compensation is a precursor (but not prerequisite) structure for the emergence of the multivariate exclusion task (see also Fig. 2; Pattern I).

3) Concerning the structural relation between concrete and formal operations (Class Inclusion and Multiple Compensation): The consolidation of the concrete-operational structure is a prerequisite condition for the emergence of transitional formal operations. For example, unidimensional conservation (concrete-operational) is a necessary condition for multiplicative conservation since it implies a transformation (INRC-group) to a second reference frame (see also Fig. 2; Pattern I).

Diachronous development (interrelation of measurement occasions for one variable)

1) Concerning the developmental relation between measurement occasion 1 and 2 (ages 7 and 9) for Class Inclusion: In accordance with the decalage hypothesis it is assumed that concrete operations develop cumulatively. Whenever an ability has been acquired at the first time of measurement, it is retained at the second time of measurement. Regarding inadmissible patterns of occurrence of one variable over time, those combinations are inadmissible which represent the acquisition of an ability at the first time of measurement and the lack of that ability at the second time of measurement (see also Fig. 2; Pattern II).

2) Concerning the relation between measurement occasion 2 and 3 (ages 9 and 12) for Multiple Compensation: As argued above for the case of development of Class Inclusion, it was also assumed that Multiplicative Compensation develops cumulatively over time (see also Fig. 2; Pattern II).

The transformation of these hypothesis into a consistent model of operatory development will be shown in Figure 4. The developmental relations are formulated in terms of statement calculus, since they adequately represent the assumed processes of development: Synchronous relations are formulated as logical implications (transitivity) and the diachronous relations as logical replication (cumulativity) (see also Fig. 2).

Insert Figure 4 about here

Admissible patterns or configurations according to the model of operatory development are shown in Table 1. Only those patterns are tabulated that are admissible with regard to the multiple relationships postulated above. The 21 admissible patterns are the results of a transformation of the constraints or conditions of the assumed model of development into binary-matrix language. For example, the pattern 11 10 00 means that only Conservation and Class Inclusion were acquired at ages 7 and 9 (occasion 1 and 2), but formal operational abilities did not emerge at ages 9 or 12 (occasion 2 and 3).

Insert Table 1 about here

Results

For the statistical evaluation of the developmental model a procedure according to Dayton & MacReady (1977) was used. This statistical program tests the fit of an empirical distribution to a postulated structure of the data. Within the procedure only those patterns are treated as true scores or "non error", which are admissible with respect to the model of operatory development. Specific statistical parameters (positive and negative error and Chi-square statistics) and the general fit of the model are shown in Table 2. In the first column the 64 possible patterns are listed. In the second column only those patterns are numbered (1 through 21) which are admissible with respect to the model. The third and fourth column stand for the observed and predicted frequencies according to the model respectively. The last column shows parameters of the Chi-Square tests. At the bottom, statistics for the general fit of the model are given.

Insert Table 2 about here

About 89% of the individual paths of development in the sample could be predicted appropriately by the operatory model of development. Only 11% showed inadmissible patterns of cognitive development. Roughly that percentage was classified as positive or negative errors according to the postulated model. In an overall

test, the model fits satisfactorily, since the general Chi-square was less than or equal to the degrees of freedom.

In this paper we do not discuss further substantial implications of this model of operatory development, since the empirical analysis serves only to demonstrate the proposed methodological approach in the analysis of developmental sequences.

Discussion

The present paper represents a contribution to the theory and methodology of the analysis of developmental sequences. The order theoretical and latent attribute procedures used here represent an advance beyond traditional procedures of analysis of variance and correlational analyses focusing on intraindividual changes in development. These strategies are characterized by attention to conceptual implications of cognitive developmental theory (task or structure analysis, order of acquisition, precursor and prerequisite structures), a methodology which specifically focuses on intraindividual changes (individual-oriented approach, formulation of developmental relations in terms of statement calculus) which generates a mathematical model which is statistically testable. Various approaches to the analysis of acquisition sequences are suggested, evaluated, and finally integrated within a consistent sequence model.

Regarding the empirical example it was shown that the development of concrete and formal operations is a highly ordered

and cumulative process showing both synchronous and diachronous development. With respect to the intraindividual changes in the emergence of operativity nearly all variations of the observed profiles of acquisition could be described and explained by the developmental model. Individuals differ in their initial cognitive status and their degree of progression or stagnation, but they do not differ with regard to the postulated developmental sequence. The results can also be interpreted as a partial replication of the investigated instruments over time. The concepts of Class Inclusion and Multiple Compensation are solved cumulatively over time (cumulativity hypothesis); in other words, there are no developmental regressions or unsystematic changes in acquisition over time. Therefore, the results represent a contribution to the analysis of micro-developmental processes.

The formulation in terms of statement calculus allows a highly complex modelling of development. It could be demonstrated that even temporal relationships (over time) can be specified precisely. Additionally, other developmental relationships (e.g. synchrony or substitution (Flavell, 1972)) can be formulated and implemented in multiple models.

The transformation of the developmental relations into the language of binary matrices and multiplicative contingency tables is an appropriate and powerful means to study sequences of development within an individual-oriented framework.

References

Bakan, D. (1967). On method: Toward a reconstruction of psychological investigation. San Francisco: Jossey-Bass.

Bart, W. M., & Airasian, P. W. (1974). Determination of the ordering among seven Piagetian tasks by an ordering-theoretic method. Journal of Educational Psychology, 66(2), 277-284.

Bart, W. M., & Krus, D. J. (1973). An ordering-theoretic method to determine hierarchies among items. Educational and Psychological Measurement, 33, 291-300.

Bergman, L. R., & Magnusson, D. (1983). The development of patterns of maladjustment. Reports from the Department of Psychology, 50, Stockholm: University of Stockholm.

Buss, A. R. (1979). Toward a unified framework for psychometric concepts in multivariate developmental situations. In J. R. Nesselroade & P. B. Baltes (Eds.), Longitudinal research in the study of behavior and development: Design and analysis (pp. 41-59). New York: Academic Press.

Campbell, R. L., & Richie, D. M. (1983). Problems in the theory of developmental sequences. Human Development, 26, 156-172.

Dayton, C. M., & MacReady, G. B. (1976). A probabilistic model for validation of behavioral hierarchies. Psychometrika, 41, 189-204.

Edelstein, W, Schröder, E., Kliegl, R., Spellbrink, W., Zebergs, D. & Baker, D. (1984). Das Projekt Kindliche Entwicklung und Soziale Struktur. In K. E. Grossmann & P. Lütkenhaus (Hrsg.), Bericht über die 6. Tagung Entwicklungspsychologie in Regensburg (Vol. 2, pp. 274-296). Regensburg: Universität Regensburg.

Edelstein, W., Keller, M., & Wahlen, K. (1984). Structure and content in social cognition: Conceptual and empirical analyses. Child Development, 55, 1514-1526.

Fischer, K. W., & Bullock, D. (1981). Patterns of data: Sequence, synchrony, and constraint in cognitive development. New Directions in Child Development, 12, 1-20.

Flavell, J. H. (1972). An analysis of cognitive-developmental sequences. Genetic Psychology Monographs, 86, 279-350.

Goldschmid, M. L., & Bentler, P.A. (1968). Manual: Concept assessment kit - Conservation. San Diego, CA: Educational and Industrial Testing Service.

Henning, H. J. (1981). Suche und Validierung kognitiver Struktur, Entwicklungssequenzen und Lern-/Verhaltenshierarchien mit Hilfe probabilistischer Modelle. Zeitschrift für Psychologie, 189, 437-461.

Hildebrand, D., Laing, J., & Rosenthal, H. (1977). Prediction analysis of cross-classifications. New York: Wiley.

Hudson, L. M. (1978). On the coherence of role-taking abilities: An alternative to correlational analysis. Child Development, 129, 223-227.

Magnusson, D. (1985). Implications of an interactional paradigm for research on human development. International Journal of Behavioral Development, 9, 115-137.

Piaget, J., & Inhelder, B. (1975). Die Entwicklung des physikalischen Mengenbegriffes beim Kinde (Vol. 4, Studienausgabe). Stuttgart: Ernst Klett Verlag.

Piaget, J., & Inhelder, B. (1977). Von der Logik des Kindes zur Logik des Heranwachsenden. Olten: Walter Verlag.

Rudinger, G. (1978). Erfassung von Entwicklungsveränderungen im Lebenslauf. In H. Rauh (Ed.), Jahrbuch für Entwicklungspsychologie (pp. 157-214). Stuttgart: Klett-Cotta.

Rudinger, G., Chaselong, F., Zimmermann, E., & Henning, H. J. (1985). Qualitative Daten, Neue Wege sozialwissenschaftlicher Methodik. München: Urban & Schwarzenberg.

Schröder, E. (1986). Entwicklungssequenzen konkreter Operationen: Eine empirische Analyse individueller Entwicklungsverläufe. Berlin: Studien und Berichte, Nr. 43, Max-Planck-Institute for Human Development and Education.

Smedslund, J. (1964). Concrete reasoning: A study in intellectual development. Monographs of the Society for Research in Child Development, 19(2), 93.

Somerville, S. C. (1974). The Pendulum problem: Patterns of performance defining developmental stages. British Journal of Educational Psychology, 44, 266-281.

Spiro, A. (June, 1984). Methods for the analysis of categorial data on developmental sequences. Paper presented at the 14th Annual Symposium of the Jean Piaget Society, Philadelphia, USA.

von Eye, A., & Brandtstädter, J. (in press). Evaluating developmental hypotheses using statement calculus and non-parametric statistics. In P. B. Baltes, D. L. Featherman, & R. M. Lerner (Eds.), Life-span development and behavior (Vol. 8). Hillsdale, NJ: Lawrence Erlbaum.

Winer, G. A. (1980). Class-inclusion reasoning in children: A review of the empirical literature. Child Development, 51(2), 309-328.

Figure Captions

Figure 1: Sequence Analysis -

Synchronous and Diachronous Perspectives

Figure 2: Types of Logical Relations and Patterns of Error

in Contingency Tables

Figure 3: Longitudinal Design of the Study -

Variables by Measureme4 Occasions

Figure 4: Model of Operatory Development

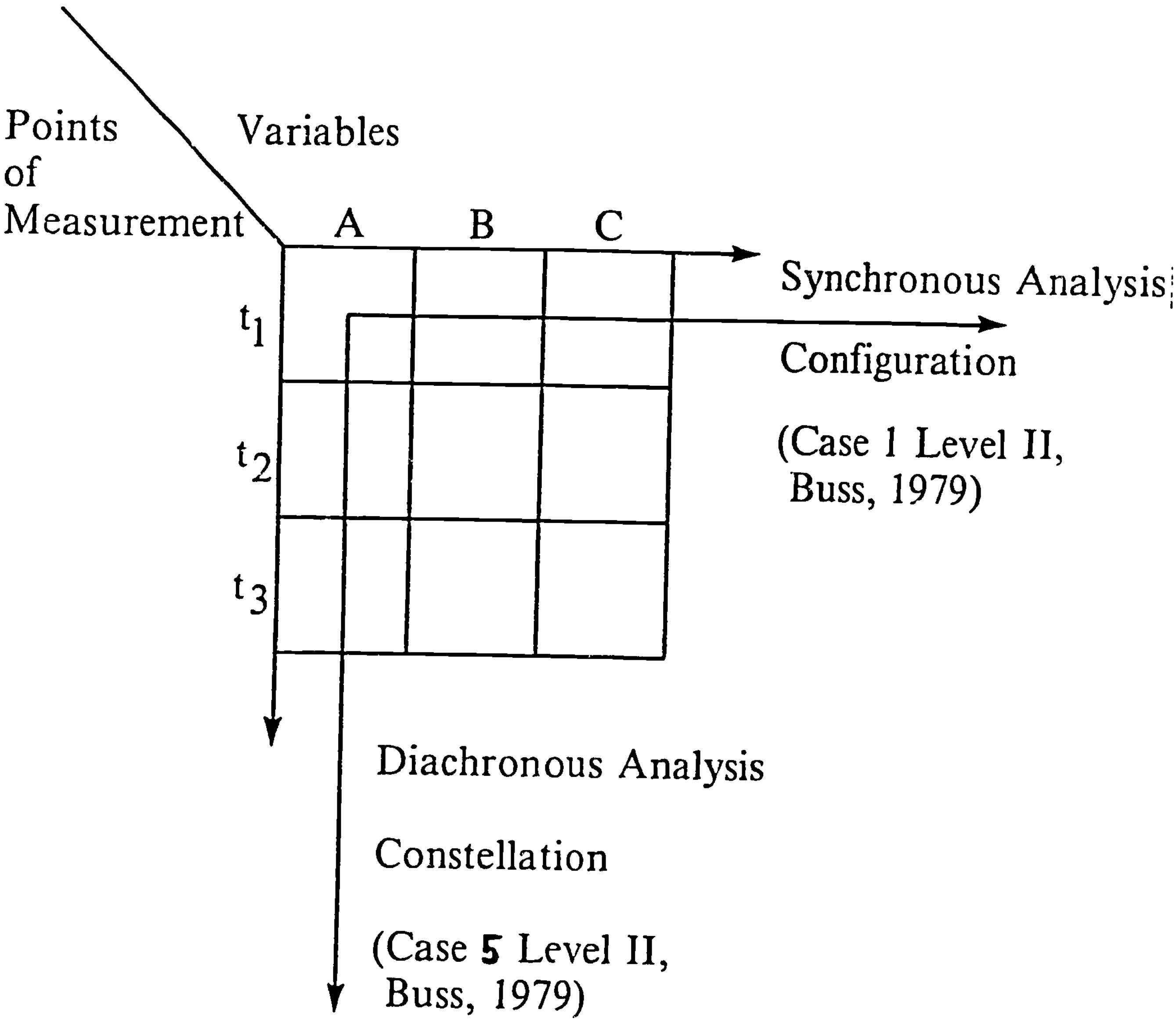
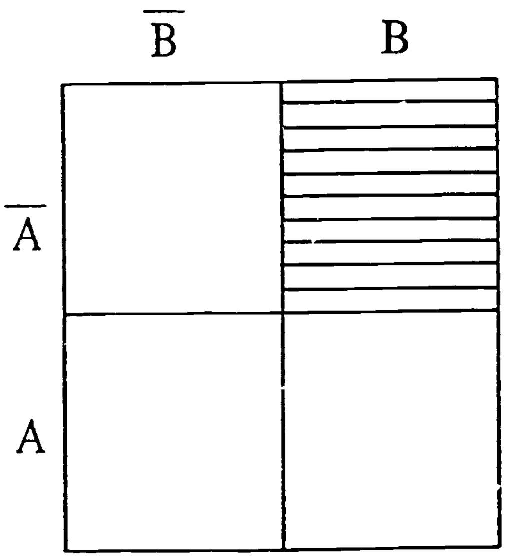
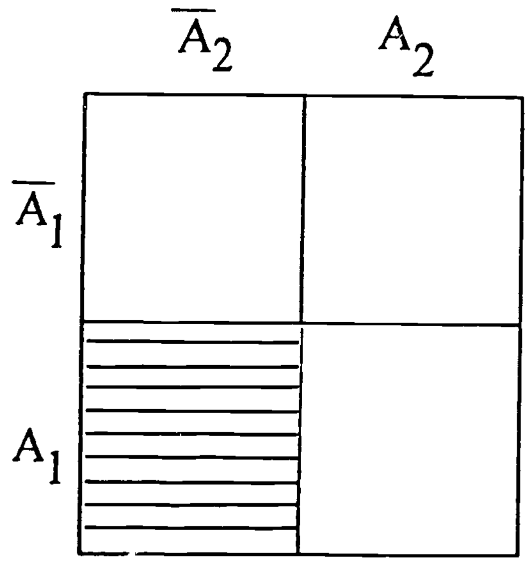

Points
of
Measurement
Variables
A
B
C
Synchronous Analysis
Configuration
(Case 1 Level II,
Buss, 1979)
t_1
t_2
t_3
Diachronous Analysis
Constellation
(Case 5 Level II,
Buss, 1979)

Fig. 1



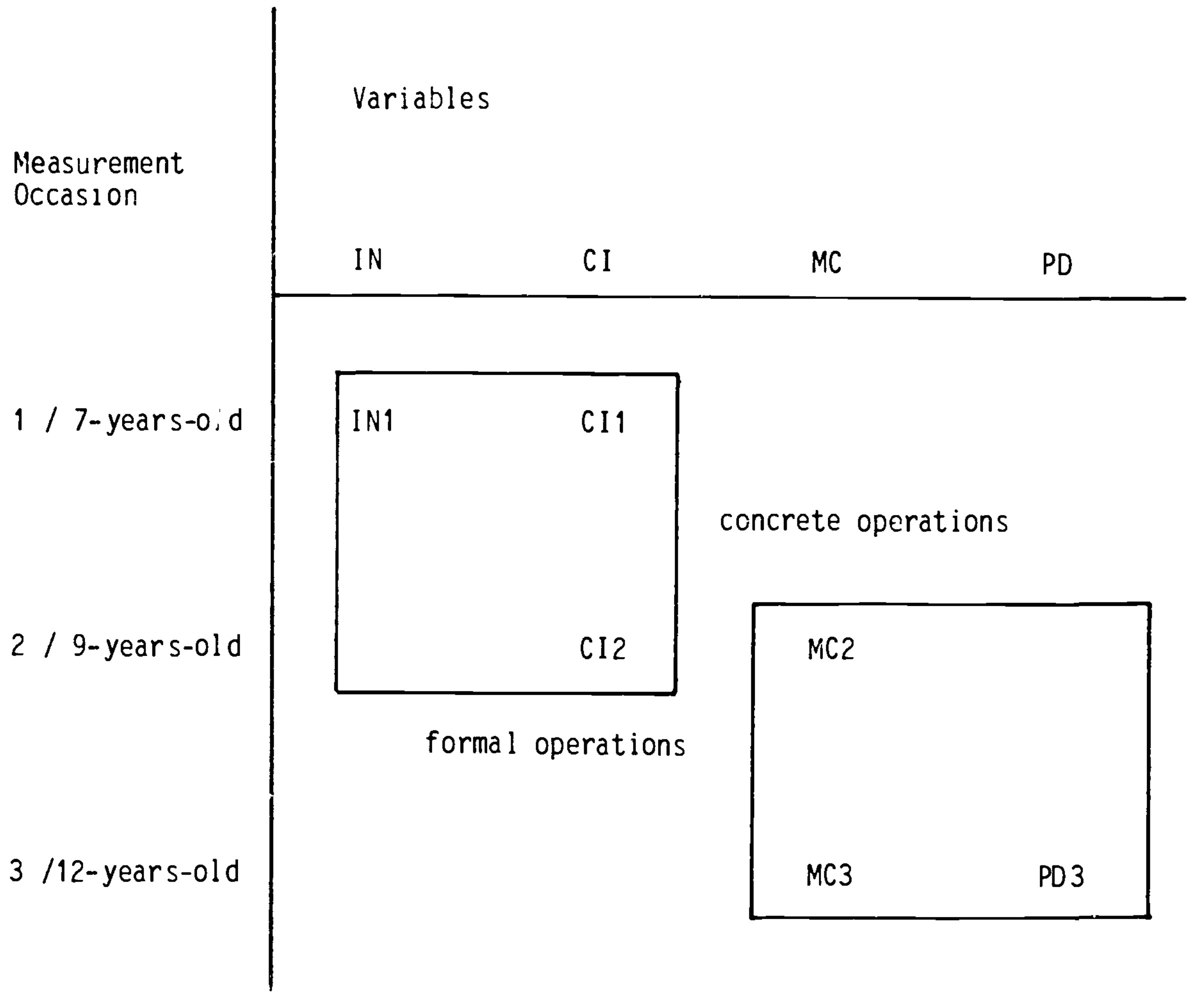


Error pattern I
Necessary condition
Logical implication

Error pattern II
Sufficient condition
Logical Replication

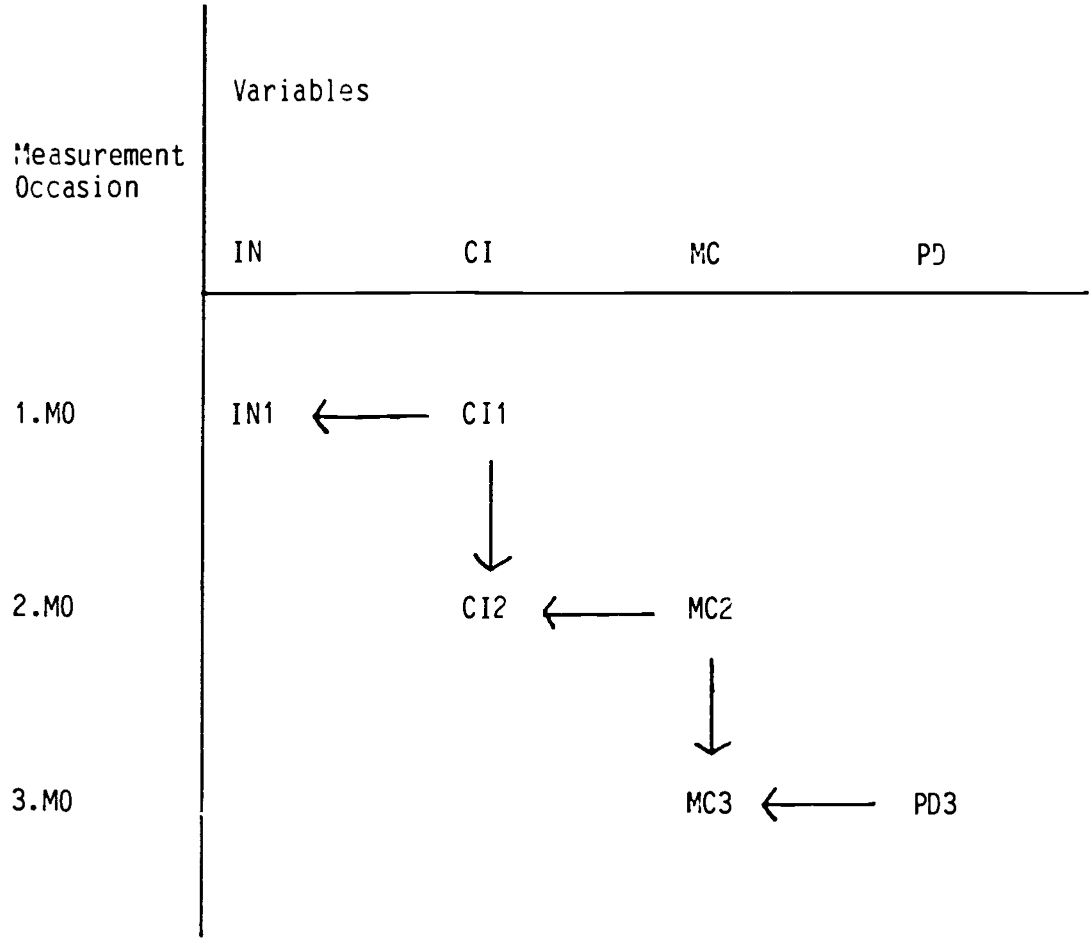
Error cells barred

Fig. 2



IN1 : Invariance of Quantity at measurement occasion 1
CI1, CI2 : Class Inclusion at measurement occasions 1 and 2
MC2, MC3 : Multiple Compensation at measurement occasion 2 and 3
PD3 : Pendulum Task at measurement occasion 3

Fig. 3



IN1 : Invariance of Quantity at measurement occasion 1
CI1, CI2 : Class Inclusion at measurement occasions 1 and 2
MC2, MC3 : Multiple Compensation at measurement occasion 2 and 3
PD3 : Pendulum Task at measurement occasion 3

← : synchronous relationship (between variables)
logical implication - necessary condition (transitivity)

↓ : diachronous relationship (between occasions)
logical replication - sufficient condition (cumulativity)

Fig. 4

Table 1: Admissible Patterns according to the Model of Development

Patterns (IN1-KI1-KI2-MC2-MC3-PD3)	No
00 00 00	1
10 00 00	2
00 10 00	3
10 10 00	4
11 10 00	5
00 00 10	6
10 00 10	7
00 10 10	8
10 10 10	9
11 10 10	10
00 11 10	11
10 11 10	12
11 11 10	13
00 00 11	14
10 00 11	15
00 10 11	16
10 10 11	17
11 10 11	18
00 11 11	19
10 11 11	20
11 11 11	21

21 admissible patterns out of 64 possible patterns

Table 2: Statistical Parameters of the Testing Model of Operatory Development (Procedure by Dayton and MacReady, 1976)

Pattern		Obs N	Pred N	Chi-Square	Pattern		Obs N	Pred N	Chi-Square
000000	1	7	6.49	0.02	000001		1	0.48	0.54
100000	2	3	2.82	0.01	100001			0.18	0.18
010000			0.44	0.44	010001			0.03	0.03
110000		1	0.61	0.23	110001			0.05	0.05
001000	3	16	17.23	0.08	001001		2	1.21	0.50
101000	4	16	14.92	0.07	101001		1	1.03	0.00
011000		2	1.49	0.16	011001		1	0.12	6.30
111000	5	5	6.09	0.19	111001		2	0.62	3.07
000100			0.41	0.41	000101			0.03	0.03
100100			0.23	0.23	100101			0.03	0.03
010100			0.02	0.02	010101			0.00	0.00
110100			0.04	0.04	110101			0.05	0.05
001100		1	1.17	0.02	001101			0.10	0.10
101100			1.59	1.59	101101			0.39	0.39
011100			0.10	0.10	011101			0.05	0.05
111100			0.48	0.48	111101			0.58	0.58
000010	(6)		0.62	0.62	000011	14	1	1.02	0.00
100010	(7)		0.89	0.89	100011	(15)		0.22	0.22
010010			0.04	0.04	010011			0.08	0.08
110010			0.10	0.10	110011		1	0.25	2.14
001010	8	3	2.85	0.00	001011	16	2	2.11	0.00
101010	9	9	9,26	0.00	101011	17	2	1.95	0.00
011010			0.22	0.22	011011			0.37	0.37
111010	(10)		1.15	1.15	111011	18	2	1.96	0.31
000110		1	0.16	4.29	000111			0.09	0.09
100110			0.74	0.74	100111		1	0.34	1.23
010110			0.01	0.01	010111			0.05	0.05
110110			0.12	0.12	110111			0.56	0.56
001110	11	1	1.63	0.24	001111	(19)		0.50	0.50
101110	12	10	8.56	0.23	101111	20	4	3.99	0.00
011110			0.17	0.17	011111		2	0.57	3.58
111110	13	2	1.40	0.24	111111	21	10	6.53	1.84

Chi-Square = 36.31 with DF = 41

alpha: 0.057
beta : 0.078

Pattern : Configuration (IN1 - CI1 - CI2 - MC2 - MC3 - PD3)
Observed N : Observed frequency
Redicted N : Predicted frequency
alpha : "Positive error" (Guessing error)
beta : "Negative error" (Forgetting error)

END

PT. OF ED

OF EDUC
SEARCH
OVEMENT

ERIC

ATE FILM

11